Estimation of groundwater flow and mass transport characteristics around a fault using environmental tracer analysis and double porosity model

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In groundwater scenario considered in the safety assessment of geological disposal of radioactive waste, radionuclides contained in the disposed radioactive waste dissolve by the action of groundwater and are transported to the human environment. To assess this scenario, it is required to understand the groundwater flow regime around disposal site. Fault serves as both of conduit and barrier for fluid flow in the crust. Therefore, understanding of hydrogeological characteristics of fault is important not only for geological disposal but also for utilization of fluid resources, such as groundwater, oil and gas, and carbon capture and storage. However, its hydrogeological and mass transport characteristics are not sufficiently understood. In this study, by using geochemical and mass transport analyses, hydrogeological and mass transport characteristics around a fault were estimated.

This study covers the area around Mizunami Underground Research Laboratory of Japan Atomic Energy Agency (JAEA), Gifu prefecture, Japan. Main shaft fault with NW-SE strike and almost vertical dip is located by the main shaft (MSF). Groundwater samples were collected in August and September of 2017 from 14 intervals of 6 boreholes in the gallery. These boreholes are located on both sides of the MSF. Concentrations or isotope ratios of dominant dissolved ions, alkalinity, hydrogen and oxygen isotopes, dissolved gases, trace elements were determined, and the spatial distribution was considered. Three-dimensional regional hydrogeological model of the watersheds including the fault was developed and groundwater flow analysis was conducted. Secondly, another model was developed for smaller area near the fault. This model has partly refined grids around the fault and its boundary conditions were set from the analysis results of the reginal model. In these models, the fault was modeled by dividing it into fault core and fracture zone, and the analysis considered unsteady drainage by construction of underground tunnels. In addition, a double porosity model considering porosities of fractured rock mass and matrix separately was applied. The porosity of matrix was converted from the result of the permeability measurement conducted in 2015 and it was set in the model considering the spatial variation dependent on distance from the fault.

It is known that spatial distributions of sodium, calcium, sulfate, chloride, bromide ion concentrations, alkalinity, hydrogen and oxygen isotope ratios, and tritium concentration were different between both sides of the fault[1]. The similar results were obtained from the analysis of groundwater samples. Additionally, methane, carbon dioxide, and nitrogen gas concentrations were higher on northeastern side of the fault, and argon gas concentration was higher on southwestern side. From the mass transport analysis for chloride ion, a large concentration change was observed only on the southwestern side of the fault. Also, the rise of deep groundwater along the fault could be confirmed. Analysis using the double domain model showed that the temporal change of chloride ion concentration was smaller on the southwestern side of the fault. This is because the macroscopic transport of the ion was delayed due to diffusion to matrix.

In the future, these models are calibrated based on actually measured values. In addition, we try to

estimate the spatial distribution and evolution in various time scales of water quality around the fault from analyses considering water-rock reaction and microbial activity.

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References

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